(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: 0 347 588 A1

(12) **EUROPEAN PATENT APPLICATION**

(21) Application number: 89109030.0

(22) Date of filing: 19.05.89

(51) Int. Cl.⁴: C08B 37/10 , A61K 31/725

Claims for the following Contracting States: ES.

(30) Priority: 10.06.88 IT 350488

(43) Date of publication of application: 27.12.89 Bulletin 89/52

(84) Designated Contracting States: AT BE CH DE ES FR GB GR IT LI LU NL SE

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(54) **Heparin derivatives and process for their preparation.**

(57) New heparin derivatives having antithrombotic activity, also endowed with reduced hemorrhagic and anticoagulant effects, obtained by treating in a basic medium heparins of various origin, optionally in the presence of alkali metal salts and of a reducing agent.

The heparin derivatives obtained through this treatment show peculiar chemico-physical characteristics, like new signals at about 53 and 54 p.p.m. in the ^{13}C-NMR spectrum and a raise of the specific rotatory power, compared to that of the starting heparins, to values between +50° to +90°.

Said structural modifications produce an improvement of the biological properties of the heparin, substantially keeping the antithrombotic activity while diminishing the hemorrhagic effect in vivo and the anticoagulant activity in vitro.

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NEW HEPARIN DERIVATIVES AND PROCESS FOR THEIR PREPARATION

BACKGROUND OF THE INVENTION

The present invention refers to new heparin derivatives having antithrombotic activity, also endowed with reduced hemorrhagic and anticoagulant effects, obtained by treating in a basic medium heparins of various origin, optionally in the presence of alkali metal salts and of a reducing agent.

It is known that heparin-like structures can be modified in various manners by treating them in a basic medium.

In European Publication EP 0133078, Mardiguian J.S., depolymerizes the heparin into oligosaccharides fractions containing from 4 to 20 saccharides units, by treating the benzyl ester of the heparin by means of an organic or inorganic base, at a concentration between 0.1 and 0.6 molar at a temperature between 20° C and 80° C. Such depolymerization is accompanied by the formation of a double bond in the positions 4 and 5 of the uronic acid, detectable by U.V. absorption at 230 nm.

Hirano S. et al., Conn. Tissue Res., 3, 73-79, 1975 depolymerize the heparin and other glycosaminoglycans in strong basic medium, by using from 2 to 10 molar concentrations of sodium or barium hydroxide at temperatures higher than 80° C. In this way they get a strong depolymerization following the cleavage of the glucosidic bond between the position 1 of glucosamine units and the position 4 of adjacent uronic units, moreover such depolymerization is accompanied by the formation of a double bond in the positions 4 and 5 of the uronic acid, detectable by means of an absorption at 225-230 nm in the U.V. spectrum.

Sampson P. and Meyer K., Proc. Nat. Acad. Sci. USA, 68, 2329-2331, 1971, obtained a structural modification in the glucosamine unit with formation of 3,6-anhydroglucosamine by treating heparin with 1N sodium hydroxide in the presence of sodium borohydride at 80° C for 7 hours.

The heparin derivatives object of the present invention totally differ from those described in the prior art. In fact they do not show the chemico-physical properties of the compounds obtained by Mardiguian J.S. and by Hirano S. et al., as it is shown by the average molecular weight which remains substantially unchanged, so proving the lack of depolymerization, and by the lack of absorption at 225-230 nm in U.V. and of peaks corresponding to the resonances of the double bond in the ^{13}C-NMR, indexes of the lack of the double bond in the positions 4 and 5 of the uronic acid. Moreover they do not even show the chemico-physical properties of the compounds isolated by Sampson P. and Meyer K. as the ^{13}C-NMR spectrum of the compounds obtained in the present invention shows unchanged the position and the intensity of the signal of the carbon atom in position 6 of the glucosamine and shows unchanged the intensity ratio between the 6-sulfated carbon atom and the 6-desulfated carbon atom that should change in case of formation of 3,6-anhydroglucosamine because of the participation of the 6-sulfated carbon atom in the formation of the anhydroderivative.

SUMMARY OF THE INVENTION

The present invention refers to new heparin derivatives, to their therapeutic use in the treatment of the thrombotic pathologies and to the process for their preparation by means of a chemical modification made in basic aqueous medium, optionally in the presence of salts and of a reducing agent, on heparins of various origin, commercial or purified by means of suitable treatments or depolymerized.

The new compounds having a modified heparinic structure possess chemico-physical properties, like specific rotatory power and ^{13}C-NMR peaks, different from those of the starting compounds and also present a different biological activity as they show a better action specificity as they keep practically unchanged the antithrombotic properties while the hemorrhagic effect and the anticoagulant power are lowered. In particular they are characterized by the fact that they show two new signals in the ^{13}C-NMR spectrum at about 53 and 54 ppm and a raise of the specific rotatory power, with respect to the starting heparins, with values between about +50° and about +90° in aqueous solution.

The chemical modification of the heparinic structure is obtained in aqueous medium at pH values higher than neutrality in the presence of a base, preferably of an alkali or an alkali-earth metal hydroxide, optionally in the presence of an alkali or alkali-earth metal salt and of a reducing substance, preferably sodium

borohydride.

The reaction is carried out for a period of time between 0.5 and 24 hours, at a temperature between about 35 °C and about 70 °C, using base concentrations between about 0.01N and about 1N and salt concentrations between 0 and about 1N, optionally in the presence of a reducing substance, like, for instance, sodium borohydride.

Alkali or alkali-earth metal bases and salts are preferably used, mainly those of sodium, potassium, calcium, magnesium and barium.

The hydroxides of sodium, potassium and barium are the bases that can be advantageously used.

The acetates and chlorides of sodium, potassium, barium, calcium and magnesium and the sulfates of sodium, potassium and magnesium are the salts that can be advantageously used.

The process of modification of the heparinic structure is carried out by dissolving the heparinic material in an aqueous solution from about 0.01N to about 1N of a base of an alkali or alkali-earth metal, optionally in the presence of a salt of an alkali or alkali-earth metal, at a concentration lower or equal than 1N, and of a catalytic amount of a reducing agent, and by thermostating the solution at a temperature between about 35 °C and about 70 °C for a period of time between 0.5 hours and about 24 hours.

At the end of the reaction the solution is cooled to room temperature, brought to neutral pH and optionally purified, for instance by means of ion exchange resins or of dialysis, and lastly the modified heparin derivative is precipitated by adding from about 2 to about 4 volumes, preferably 2.5 volumes, of an alcohol containing from 1 to 3 carbon atoms, like for instance ethyl alcohol.

The modified heparins obtained in this process show some peculiar chemico-physical characteristics which are totally different from those coming from the alkali treatments known from the prior art. This is due to the reaction conditions used in the present invention where the values of the parameters, mainly as regards the base concentration, the temperature and the optional presence of a salt, are significantly different from those previously used.

The structural changes of the new heparin derivatives have been principally shown from the position and the relative intensity of the resonances in the ^{13}C-NMR spectrum and also from the electrophoretic behaviour, from the raise of the values of the specific rotatory power and from the decrease of the sulfur content and of the sulfates/carboxyls ratio, being unchanged the carboxyls content.

The more characteristic changes in the structure of the new heparin derivatives have been checked through the study of the deep changes occurred in the ^{13}C-NMR spectrum. There variations refer to some specific zones of the spectrum and involve both the appearance of new peaks and the modification of other peaks. Of noteworthy importance is the appearance of two new signals at about 53 and about 54 ppm and the shifts of the peaks corresponding to the carbon atom 1 of the iduronic and glucosaminic unit in the zone between 92 ppm and 102 ppm. The comparative check of the ^{13}C-NMR spectra of the new compounds and of those of the starting compounds enable us to establish that some zones of the spectrum are unchanged and that consequently some portions of the heparinic structure have not been modified at all. In particular, the signals related to the position 6 of the sulfated or desulfated glucosamine unit have not been modified. Moreover, the peaks related to the position 2 of the glucosamine units, sulfated or acetylated, to the carboxy group of the iduronic acid and to the units of glucuronic acid, which in the heparin form an average of the 20% of the uronic residues, are unchanged.

The chemico-physical characteristics of the new heparin derivatives result the more modified the more drastic are the reaction conditions, as it can be inferred from the not limiting described examples. Therefore the modulation of the parameters of the reaction makes possible the obtaining of compounds more or less deeply modified in their structure.

The amount of the chemical modification can be calculated by doing the ratio between the sum of the integrals of the peaks at about 53 and about 54 ppm and the sum of the integrals of the peaks of the carbon atom in the position 6 of the glucosamine unit, at about 62.5 and about 69 ppm, these latter being selected as an arbitrary reference because their intensity remains stable and because they are in a spectrum zone free from other peaks. Parallelly to the raise of the resonances at about 53 and about 54 ppm there is an increase of the rotatory power at 589 nm (D line of sodium) and therefore the measurement of the specific rotatory power can be directly used for the evaluation of the degree of the chemical modification occurred in the heparinic structure. As optically active reagents are not used in the reaction medium, the measurement of the rotatory power can be directly used for the check of the course of the reaction.

Both the ratios of the integrals of the peak of the ^{13}C-NMR and the increase of the specific rotatory power in respect of the starting compound are reported in the following table 1.

TABLE 1

EXAMPLE	Area of peaks at 53 and 54 ppm / Area of peaks at 62.5 and 69 ppm	Difference among the specific rotatory powers of the modified and the starting heparins $[\alpha]_D^{20}$
5	0.15	+ 5°
6	0.25	+ 7°
7	0.30	+ 7°
4	0.45	+ 10°
1	0.55	+ 18°
2	0.75	+ 22°
3	1.20	+ 29°

These modified heparins are moreover characterized in that they possess a different electrophoretic behaviour from that of the starting compounds, characterized by a greater mobility in barium acetate buffer 0.1M at pH 5.8 [P. Oreste, G. Torri, J. Chrom. 195, 398, (1980)], and in that they have a sulfur content between about 8% and about 11%, a sulfates/carboxyls ratio between about 1.50 and about 2.20 and a specific rotatory power $[\alpha]_D^{20}$ between about +50° and about +90° as it is shown by the following table 2 where, in brackets, the values of the corresponding starting compounds are reported.

TABLE 2

EXAMPLE	% sulfates		sulfates/carboxyls ratio		$[\alpha]_D^{20}$
5	10.31	(11.40)	2.17	(2.27)	+50° (+45°)
6	10.69	(11.60)	2.15	(2.32)	+54° (+47°)
7	9.70	(11.00)	1.90	(2.00)	+51° (+44°)
4	9.65	(10.56)	2.03	(2.20)	+57° (+47°)
1	8.95	(10.56)	1.94	(2.20)	+65° (+47°)
2	8.42	(10.09)	1.64	(2.13)	+65° (+43°)
3	8.12	(10.09)	1.56	(2.13)	+72° (+43°)

The new heparin derivatives, object of the present invention, possess a marked antithrombotic activity together with a lower anticoagulant effect in respect of the starting heparins. Their biological activity was assessed through many typical tests of the heparins; precisely the tests of the anti-Xa factor, of APTT, of the bleeding time and of the protection from the experimental thrombosis were carried out. The APTT activity was determined according to the method of Larrieu M.J. and Weiland G., Rev. Hematol., 12, 199, (1957), while the anti-Xa activity was determined according to the method of Yin E.T. and Wessler S., Biochem. Biophys. Acta, 201, 387, (1970).

Every examined compound was dissolved in plasma taken from fasting rats, then proportional dilutions were made to obtain the concentrations provided for by the method. Ten determinations were performed for both activities for each compound and the quantity that causes a highly significant change in the corresponding test was calculated in mcg/ml. In particular, the activity of each product was expressed as

the concentration, in mcg/ml, that respectively doubles the APTT time and that increases the anti-Xa value of 30%. The values obtained in the two tests (see table 3) confirm that the new compounds show a diminution of the anticoagulant power.

The bleeding time was carried out in the rat according to the method described by Dejana E. et al, Thromb. Haemost., 48, 108, 1982 and the result was expressed by calculating the percent of the time of the bleeding elongation in the rats treated with the new heparins in comparison with the time of bleeding elongation in the rats treated with the corresponding starting heparins considered equal to 100%. All the new derivatives having modified heparinic structure, object of the present invention, showed a decrease, often very marked, of the bleeding time, in comparison with the corresponding starting heparins.

The antithrombotic activity was assessed by the test of the stasis venous thrombosis described by Reyers S. et al. Thromb. Res. 18, 669-74, 1980. The protection afforded by the new compounds was calculated, in percent, by taking equal to 100 the antithrombotic protection given by the starting heparins.

The obtained results showed a substantial equivalence of the two series of heparins as regards this test on the antithrombotic activity.

The values of the above described biological tests are summarized in the following table 3 where the anti-Xa and the APTT values of the corresponding starting heparins are reported within brackets.

TABLE 3

EXAMPLE	Anti-Xa Activity		APTT Activity		Bleeding time.	Antithrombotic protection % in comparison with the starting heparinic material
	Amount of compound which increases the anti-Xa value of 30% (mcg/ml)		Amount of compound which doubles the APTT time (mcg/ml)		% Elongation in comparison with the starting heparinic material	
1	30.2	(20.6)	4.2	(1.7)	22	100
2	33.7	(18.6)	8.9	(1.9)	83	117
3	43.5	(18.6)	16.3	(1.9)	11	53
4	18.1	(20.6)	4.8	(1.7)	60	75
5	21.0	(16.5)	11.5	(10.8)	9	113
6	44.0	(40.6)	8.8	(8.5)	30	113
7	19.6	(18.2)	2.6	(2.0)	30	88

In view of the above seen pharmacological properties, these new heparin derivatives are useful for treating thrombotic pathologies. The preferred ways of administration are the parenteral and the subcutaneous ones in form of sterile aqueous solutions, optionally containing also some salts, in order to make the solution isotonic, and some preserving agents.

The dosage range depends on the used pharmaceutical formulations and on the state of the patient; in a preferred way, an amount of heparin derivative, according to the present invention, equivalent to between 5,000 and 20,000 Units of anti-Xa factor (U.A.Xa) is administered one or more times a day.

As the starting substrates, heparinic materials of different origin can be employed. For example, commercial heparins and heparins purified by treatment of commercial heparins, as well as low molecular weight heparins, obtained by depolymerization according to methods known in the art, were employed in order to get the modified heparins object of the present invention. Underneath, we show the preparation of the starting heparinic materials used in the present invention.

Sodium heparin ALFA 87-78

25 Grams of commercial sodium heparin are dissolved in 2000 ml of water and poured in about 30 minutes into a solution containing 111.2 g of calcium acetate monohydrate in 2000 ml of water, 57 ml of acetic acid and 600 ml of ethyl alcohol, while keeping the temperature at about 8° ÷ 10° C. The obtained suspension is filtered after 15 hours at 5° C and the filtrate is added with 1000 ml of ethyl alcohol and after 3 hours at 5° C the obtained precipitate is filtered. The precipitate is then dissolved in 200 ml of water, the solution is brought to ph 7.0 by means of sodium hydroxide 1N and then it is treated with 100 ml of Dowex 50W X8, sodium form, resin and with 70 ml of water for 20 minutes. Solution and resin are transferred into a chromatograpphic column (ø = 1.6 cm, h = 10 cm) containing 80 ml of the same resin. After having percolated the solution and eluted it with distilled water until a total volume of solution equal to 400 ml, said solution is added with 12 g of sodium acetate trihydrate and with 1000 ml of ethyl alcohol. The precipitate is filtered and dried under vacuum obtaining 19.2 g of purified sodium heparin named ALFA 87-78 having the following chemico-physical characteristics:
S = 10.09 %, sulfates/carboxyls ratio = 2.13,
$[\alpha]_D^{20}$ = +43° (C = 1% in H_2O)
^{13}C-NMR spectrum (ppm): 177.3; 104.7; 102.0; 99.4; 80.0; 78.6; 72.3; 71.9; 69.0; 62.5; 60.6.

Sodium heparin ALFA 87-81

It was obtained by means of the same method of purification used for ALFA 87-78 starting from 50 g of the same commercial heparin.

36,5 Grams of purified heparin were obtained having the following chemico-physical characteristics:
S = 10,56%; sulfates/carboxyls ratio = 2.20
$[\alpha]_D^{20}$ = + 47° (C = 1% in H_2O)
^{13}C-NMR spectrum (ppm): 177.3; 104.7; 102.0; 99.5; 80.1; 78.6; 72.4; 72.0; 69.1; 62.7; 60.7.

Commercial sodium heparin

It is a heparin having the following chemico-physical characteristics:
S = 11.0%; sulfates/carboxyls ratio = 2
$[\alpha]_D^{20}$ = + 44° (C = 1% in H_2O)
^{13}C-NMR spectrum (ppm): 177.4; 104.6; 101.9; 99.8; 79.9; 78.6; 72.2; 71.8; 69.0; 62.6; 60.6.

Low molecular weight sodium heparin LMW ALFA 86-02

The low molecular weight sodium heparin LMW ALFA 86-02 was prepared by depolymerization with hydrogen peroxide in presence of cupric ions according to the method described in the international patent publication WO 86/06729.

It shows the following chemico-physical characteristics:
average molecular weight: 4200 daltons,

S = 11.40%; sulfates/carboxyls ratio = 2.27
$[\alpha]_D^{20}$ = + 45° (C = 1% in H_2O)
^{13}C-NMR spectrum (ppm): 177.4; 104.6; 101.9; 99.8; 79.9; 78.6; 72.6; 72.2; 71.9; 69.1; 62.7; 60.7.

<u>Low molecular weight sodium heparin LMW ALFA 87-198</u>

The low molecular weight sodium heparin LMW ALFA 87-198 was prepared by depolymerization according to the method used for LMW 86-02.

It shows the following chemico-physical characteristics:
S = 11.60%; sulfates/carboxyls ratio = 2.32
$[\alpha]_D^{20}$ = + 47° (C = 1% in H_2O)
^{13}C-NMR spectrum (ppm): 177.7; 104.8; 102.0; 99.6; 80.2; 78.6; 72.4; 71.9; 69.2; 62.7; 60.6.

The determination of the values of the specific rotatory power $[\alpha]_D^{20}$ was carried out in aqueous medium at a concentration of 1%.

The determination of the sulfates/carboxyls ratio was executed by potentiometric way.

The determination of the sulfur percentage was carried out both with the potentiometric method and with the Schoeniger method.

The ^{13}C-NMR spectra were executed at 75.47 MHz with a Varian CFT-75 spectrometer by using D_2O as solvent and sodium 3-trimethylsilylpropansulfonate as reference internal standard.

The following examples have to be considered as an explanation of the present invention and not as an its limitation.

<u>EXAMPLE 1</u>

1.8 Grams of heparin ALFA 87-81 are added to 45 ml of an aqueous solution containing 0.4 g of sodium hydroxide (0.225 N), 2.3 g of sodium acetate (0.625 N) and 10 mg of sodium borohydride. The obtained solution is thermostated at 60° C for 3.5 hours, then it is cooled to room temperature, brought to neutrality with glacial acetic acid and added with 2.5 volumes of ethanol. The precipitate is filtered, washed on the filter with a 6:1 ethanol/water mixture and dried. 1.7 Grams of product are obtained having a ^{13}C-NMR spectrum that shows characteristic signals at the following δ (expressed as ppm): 177.3; 104.3; 101.9; 99.4; 98.4; 97.2; 96.8; 79.7; 79.1; 78.5; 72.1; 71.8; 71.2; 68.8; 62.4; 60.6; 60.3; 54.1; 53.1.

<u>EXAMPLE 2</u>

1.8 Grams of heparin ALFA 87-78 are added to 45 ml of an aqueous solution containing 0.4 g (0.225 N) of sodium hydroxide, 2.3 g of sodium acetate (0.625 N) and 10 mg of sodium borohydride. The solution is thermostated at 60° C for 15 hours and, after cooling, it is brought to neutrality with acetic acid and then it is percoled thru a column (Ø = 1.2 cm, h = 8 cm) containing Dowex 1 X 2, chloride form, anionic resin. The percolate and the washings are collected together and added with 2.5 volumes of ethanol. The precipitate is filtered, washed on the filter with a 6:1 ethanol/water mixture and dried. 1.65 Grams of product are obtained having a ^{13}C-NMR spectrum that shows characteristic signals at the following δ (expressed as ppm): 177.4; 104.6; 101.8; 98.6; 97.2; 96.8; 79.6; 79.1; 78.9; 72.2; 71.5; 71.2; 68.8; 62.5; 60.3; 54.1; 53.1.

<u>EXAMPLE 3</u>

1.8 Grams of heparin ALFA 87-78 is added to 120 ml of an aqueous solution containing 4.8 g (1 N) of sodium hydroxide. The solution is thermostated at 60° C for 3.5 hours, brought to neutrality with acetic acid and dialyzed for one night with running water and for 6 hours with distilled water. The solution is then added with 3.5 g of sodium acetate, brought to neutrality with acetic acid and added with 2.5 volumes of ethanol. The precipitate is filtered, washed with a 6:1 ethanol/water mixture and dried. 1.7 Grams of product are obtained having a ^{13}C-NMR spectrum that shows characteristic peaks a the following δ (expressed as ppm):

177.4; 104.6; 101.7; 98.6; 98.4; 97.2; 96.8; 79.7; 79.1; 78.6; 73.5; 72.5; 72.3; 72.1; 71.5; 68.8; 62.6; 60.4; 60.2; 54.0; 53.1.

EXAMPLE 4

4 Grams of heparin ALFA 87-81 are added to 120 ml of an aqueous solution containing 4.8 g (1 N) of sodium hydroxide, 6.2 g (0.625 N) of sodium acetate and 25 mg of sodium borohydride. The reaction mixture is thermostated at 60° C for 3.5 hours, then it is neutralized with acetic acid, dialyzed for 24 hours with running water and percolated thru a Dowex 1 X 4, chloride form, anionic resin (ø = 1.6 cm, h = 15 cm). The percolate and the washings are added with 4 g of sodium acetate and 2.5 volumes of ethanol. The precipitate is filtered and washed on the filter with a 6:1 ethanol/water mixture and dried. 3.55 Grams of product are obtained having a ^{13}C-NMR spectrum that shows characteristic peaks at the following δ (expressed as ppm): 177.4; 104.5; 101.8; 99.4; 98.7; 97.1; 79.5; 78.6; 73.5; 71.8; 68.8; 62.4; 60.3; 54.0; 53.1.

EXAMPLE 5

1.8 Grams of heparin LMW ALFA 86-02 are added to 50 ml of an aqueous solution containing 0.08 g (0.04 N) of sodium hydroxide, 2.6 g (0.625 N) of sodium acetate and 10 mg of sodium borohydride. The reaction mixture is thermostated at 60° C for 210 minutes, then it is cooled to room temperature and is percoled first on a column of anionic resin Dowex 1X4, OH^- form (ø = 1.2 cm, h = 10 cm) and then on a column of cationic resin Dowex 50 WX8, H^+ form (ø = 1.2 cm; h = 10 cm). The percolate and the washings are brought to neutrality by means of a 2 N aqueous solution of sodium hydroxide and then are added with 4 g of sodium acetate and with 2.5 volumes of ethanol. The obtained precipitate is washed with a 6 : 1 ethanol/water mixture and dried. 1.4 Grams of product are obtained having a ^{13}C-NMR spectrum that shows characteristic peaks of the following δ (expressed as ppm): 177,4; 104.6; 101.9; 99.4; 98.6; 98.4; 97.2; 96.8; 79.9; 78.6; 72.3; 71.9; 68.8; 62.6; 60.3; 54.1; 53.1.

EXAMPLE 6

10 Grams of heparin LMW ALFA 87-198 are added to 300 ml of an aqueous solution containing 2.7 g (0.225 N) of sodium hydroxide, 15 g (0.625 N) of sodium acetate and 60 mg of sodium borohydride. The solution is thermostated at 60° C for 50 minutes, cooled to room temperature, diluted to 500 ml with distilled water and percoled first on anionic resin Dowex 1 X 2, OH^- form (ø = 2 cm; h = 15 cm) and then on cationic resin Dowex 50 W X 8, H^+ form (ø = 2 cm; h = 15 cm). The percolate and the washings are brought to neutrality by means of a 4 N aqueous solution of sodium hydroxide and then are added with 20 g of sodium acetate and 2.5 volumes of ethanol. The obtained precipitate is washed with a 6 : 1 ethanol/water mixture and dried. 9.1 Grams of product are obtained having a ^{13}C-NMR spectrum that shows characteristic peaks at the following δ (expressed as ppm): 177.4; 104.6; 101.9; 99.8; 98.6; 98.4; 97.2; 96.8; 79.8; 78.6; 72.2; 71.8; 68.9; 62.5; 60.3; 54.1; 53.1.

EXAMPLE 7

15 Grams of commercial sodium heparin are added to 600 ml of an aqueous solution containing 5.4 g (0.225 N) of sodium hydroxide, 30 g (0.625 N) of sodium acetate and 120 mg of sodium borohydride. The solution is thermostated at 42° C for 4 hours, cooled at room temperature and brought to neutrality with acetic acid. The solution is dialyzed for one night with running water and then is percoled on a column of anionic resin Dowex 1X2, chloride form (ø = 2.8 cm; h = 15 cm). The percolate and the washings are added with 10 g of sodium acetate, brought to pH 7 by means of a 2 N aqueous solution of sodium hydroxide and added with 2.5 volumes of ethanol. The obtained precipitate is washed with a 6 : 1 ethanol/water mixture and dried. 13.9 Grams of product are obtained having a ^{13}C-NMR spectrum that

shows characteristic peaks at the following δ (expressed as ppm): 177.3; 104.6; 101.9; 99.8; 98.6; 98.4; 97.2; 96,8; 79.9; 78.6; 72.2; 71.8; 69.0; 62.5; 60.3; 54.1; 53.1.

EXAMPLE 8

A vial for parenteral use contains:

- heparin modified according to Example 1...	10.000 U.A.Xa
- F.U. sodium chloride F.U. ...	5 mg
- B.P Benzyl alcohol...	8 mg
- bidistilled sterile water...	1 ml

Claims

1) New heparin derivatives characterized by signals in the ^{13}C-NMR spectrum at about 53 and about 54 ppm, specific rotatory power between about +50° and about +90° in aqueous solution, sulfur content between about 8% and about 11% and sulfates/carboxyls ratio between about 1.50 and about 2.20.

2) Process for the preparation of new heparinic derivatives characterized by signals in the ^{13}C-NMR spectrum at about 53 and about 54 ppm, specific rotatory power between about +50° and about +90° in aqueous solution, sulfur content between about 8% and about 11% and sulfates/carboxyls ratio between about 1.50 and about 2.20, which comprises treating an aqueous solution of a heparinic material with a base of an alkali or alkali-earth metal at a concentration between about 0.01 N and about 1 N, in the presence of a concentration between 0 and about 1 N of a salt of an alkali or an alkali-earth metal, facultatively in the presence of a catalytic amount of a reducing agent, for a period of time between 0.5 and 24 hours at a temperature between about 35° C and about 70° C, optionally purifying the reaction mixture by percolation thru a ionic exchange resin or by dialysis, and precipitating the compounds having the so modified structure by adding from about 2 to about 4 volumes of an alcohol containing from 1 to 3 carbon atoms at a pH about neutral.

3) Process according to claim 2 wherein the base is selected among sodium, potassium and barium hydroxides.

4) Process according to claim 2 wherein the salts are selected among the sodium, potassium, barium, calcium and magnesium chlorides and acetates and the sodium, potassium and magnesium sulfates.

5) Process according to claim 2 wherein the reducing agent is the sodium borohydride.

6) Process according to claim 2 wherein the compounds are precipitated by adding about 2.5 volumes of ethyl alcohol.

7) Use of the compounds of claim 1 for the preparation of pharmaceutical formulations for treating thrombotic pathologies.

Claims for the following Contracting State: ES

1) Process for the preparation of new heparinic derivatives characterized by signals in the ^{13}C-NMR spectrum at about 53 and about 54 ppm, specific rotatory power between about +50° and about +90° in aqueous solution, sulfur content between about 8% and about 11% and sulfates/carboxyls ratio between about 1.50 and about 2.20, which comprises treating an aqueous solution of a heparinic material with a base of an alkali or alkali-earth metal at a concentration between about 0.01 N and about 1 N, in the presence of a concentration between 0 and about 1 N of a salt of an alkali or an alkali-earth metal, facultatively in the presence of a catalytic amount of a reducing agent, for a period of time between 0.5 and 24 hours at a temperature between about 35° C and about 70° C, optionally purifying the reaction mixture by percolation thru a ionic exchange resin or by dialysis, and precipitating the compounds having the so modified structure by adding from about 2 to about 4 volumes of an alcohol containing from 1 to 3 carbon atoms at a pH about neutral.

2) Process according to claim 1 wherein the base is selected among sodium, potassium and barium hydroxides.

3) Process according to claim 1 wherein the salts are selected among the sodium, potassium, barium, calcium and magnesium chlorides and acetates and the sodium, potassium and magnesium sulfates.

4) Process according to claim 1 wherein the reducing agent is the sodium borohydride.

5) Process according to claim 1 wherein the compounds are precipitated by adding about 2.5 volumes of ethyl alcohol.

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 89 10 9030

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
A	J. BIOCHEM., vol. 86, 1979, pages 147-153; M. KOSAKAI et al.: "Stability of ester sulfates in heparin to solvolysis and dilute acid treatment"		C 08 B 37/10 A 61 K 31/725
A	BIOCHEM. J., vol. 175, 1978, pages 288-309, GB; L.-A. FRANSSON et al.: "Alpha-L-iduronate ring conformations in heparin and heparin derivatives" * Page 304, table 2 *		
A	MACROMOLECULES, vol. 12, no. 5, September/October 1979, pages 1001-1007, American Chemical Society; G. GATTI et al.: "Studies on the conformation of heparin by 1H and 13C NMR spectroscopy"		
A	CARBOHYDRATE RESEARCH, vol. 145, 1986, pages 267-277, Elsevier Science Publishers B.V., Amsterdam, NL; L. AYOTTE et al.: "N.M.R. spectroscopic observations related to the function of sulfate groups in heparin. Calcium binding vs. biological activity" * Page 276, paragraph 2; page 268, scheme 1 *		TECHNICAL FIELDS SEARCHED (Int. Cl.4) C 08 B
A	CHEMICAL ABSTRACTS, vol. 76, 1972, pages 265-266, abstract no. 57073z, Columbus, Ohio, US; S. OGREN et al.: "Degradation of heparin in mouse mastocytoma tissue", & BIOCHEM. J. 1971, 125(4), 1119-29		

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	29-09-1989	LENSEN H.W.M.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
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T : theory or principle underlying the invention
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& : member of the same patent family, corresponding document